家蠶の絹絲腺研究豫報

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PRELIMINARY NOTE ON THE SILK GLANDS OF BOMBYX MORI.

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In my recent studies on the silk glands of the domestic silkworm *(Bombyx mori)* I come to conclusions differing greatly from those of previous authors. I will enumerate in the following pages the chief points obtained.

1) There are two pairs of long slender muscles standing in relation to the silk glands. A pair of these muscles attaches to the middle division [1], and the other to the posterior division of the glands. They tie up various parts of the silk glands by means of connective tissue tendons. As it appears to me, they afford in this way an important service to give to the glands the certain fashion of its loopings and convolutions. Concerning their histological nature, the silk glands themselves are, in contrast to the remarks made by A. LENTICCHIA [2], not muscular at any rate.

2) Numerous tracheal tubes of various sizes stand in connection with the middle and the posterior division, but not with the anterior division at all. These tracheal tubes not only supply air to the secretory cells, but they are subserved in

1) In the silk gland there are generally distinguished four parts, respectively named filière, excretory tube, reservoir and secreting tube, according to the physiological function of each part which is so assumed. As will, however, be seen in future pages, this assumption is partly incorrect. I prefer, therefore, the terms *anterior*, *middle* and *posterior* division for last three parts, while the term filière is retained.

2) *Bollettino di Serisoltura.* Anno XIII, No. 46, pp 468, 1906.

supporting the glands so as to fix them in their positions. They peneterate deep into the bodies of the gland-cells, piercing through the tunica propria. In the first step of this penetration, the propria, which is highly elastic, is not bored, as one might presume, by the pushing force of the growing tips of tracheæ; but this elastic lamella is dissolved, in points of contact with the tracheal tips, by some enzyme substance secreted from the latter. The tracheal tubes which penetrated the glands branch repeatedly, to be at last divided into finest capillaries, which show no trace of tænidia and are lost in free termination within the cytoplasm; in this way, they become distributed everywhere in the cell-bodies. In spite of my efforts, no traces of socalled "Tracheenkapillarendnetz" by WISTINGHAUSEN [1] have been observed. Every ecdysis is preceded by a formation of a new series of tænidia coming into view immediately beneath the peritoneal cells. Therefore, on cross sections through the gland in this stage, the old tænidian ring is revealed inside a new one. Furthermore not unfrequently, double rings of old tænidia surrounded with a new ring are seen.

3) Contrarily to the observation by G. JOSEPH [2], there is found no trace of nerves standing in connection with the silk glands. The connective tissues and tracheal tubes, ramifications of which are in close resemblance to nerve fibres, are probable to be mistaken for nerves.

4) Tunica intima in the anterior division is a continuous layer provided with fine radial striations. The spiral markings are observed, on the intima of the middle division, by some previous authors; but their peculiar condition in the posterior division is, so far as I am aware, yet noticed by none. The spiral markings on the intima are regular in arrangement and run in parallel in the middle division, and is gradually disturbed towards the hinder part of the gland, so that they are converted into a net-form markings.

5) In the silken column contained in the gland-lumen are distinguishable two distinct layers, the sericin and the fibroin. Views of previous authors concerning the silk formation or the production of the sericin and fibroin are widely divergent from one another. BOLLEY's view may be looked upon as having totally been abandoned. GILSON's "selection" theory [3] appears also to be hardly intelligible. The

1). C. v. Wistinghausen: Tracheenendigungen in den Sericterien der Raupen. *Zeitschr. f. wiss. Zool.* XLIX, 1890. pp 565-582.

2). G. Joseph: Vorläufige Mitteilung über Innervation und Entwickelung der Spinnorganen bei Insekten. *Zool. Anzeig.* 1880. pp 326-328.

3). G. Gilson: Recherches sur les céllules sécrétantes. La soie et appareils sericigènes. *La cellule.* 1890, 1893.

views generally accepted at present are the following two: 1) the fibroin is secreted from the posterior division, and the sericin from the middle division (HABERLANDT [1], LIDTH DE JEUDE [2], MAILLOT et LAMBERT [3] etc.); 2) the sericin is formed in the middle division by some chemical changes performed in the periphery of the fibroin mass, which is secreted from the posterior division (BLANC [4], SILBERMANN [5], etc.). Both these views are, as I believe, occasioned by failure in detecting the sericin in the posterior division. On the contrary, I have made out, in fact, the distinct sericin cover surrounding the fibroin column in the division in question, especially in the individuals fixed just after a moult. Fixed material reveals not unfrequently an irregular layar of the fibroin covering the sericin ring; furthermore, the fibroin layer is connected by its processes with the gland-wall, a fact which affords undisputable evidence in proving the fibroin secretion of the middle division. From the facts above mentioned, I will be permitted to draw the following conclusions in regard the silk formation: the fibroin is secreted not only from the posterior division, but also from the middle division, and that the sericin is transformed from the fibroin itself under influence of the air in the lumen of the gland. The chemical changes in question occur usually in the middle division; however, the processes take place also in the posterior division, as this is observable in certain periods. The usual absence of the sericin in the latter division is due to the transportation of the fibroin which is carried on, in the period of active secretion, so quickly that the fibroin secreted escapes the chemical changes therein. On the other hand, the sericin is formed abundantly in the middle division simply because the fibroin column stays here for an interval of time ample to undergo the chemical action in its peripheral part, being as it were, sustained by the suddenly narrowed passage from the division in question into the anterior division. On the contrary, in the case of inactive secretion, as it happens not unfrequently in individuals which have just finished a moult, the fibroin naturally does not quickly leave the

1) F. Haberlandt: Der Seidenspinner des Maulbeerbaumes, seine Anzucht und Krankheiten. Wien. 1871.

2) Lidth de Jeude: Zur Anatomie und Physiologie der Spinndrüsen der Seidenraupe. *Zool. Anzeig.* 1878. pp 100-102.

3) E. Maillot et F. Lambert: Traité sur le ver a soie du murier et sur le murier. Montpéllier. 1906.

4) L. Blanc: Étude sur la sécrétion de la soie et la structure des brin et de la bave dans le *Bombyw mori*. Lyon. 1889.

5) H. Silbermann: Die Seide. Dresden. 1897.

place secreted, so that it satisfactorily undergoes therein the transformation into the sericin. In this way we find, in the posterior division, the sericin layer covering the fibroin mass.

6) As to the motive of shifting forwards the silken column in the lumen of the gland, there is no intelligible view advanced by previous authors. Some authors ascribe this partly to the action of so-called flière in the spinneret and partly to the blood pressure. The silken column in the gland-lumen, however, is not a solid body, but nothing more than a viscous fluid; then, the first half of this view self-evidently loses its power; the second half is unintelligible, because the pressure of blood, which slowly flows *backwards* in the so-called body cavity of caterpillar, may not act as motive pressing *forwards* the secretes. In my opinion, the motive force in question is quite different. Numerous air-bubbles are seen in the interior of the silken column, and a large air-reservoir is found between the inner wall of the secretory cells and the central silken column, a fact which is so striking that it may not be overlookd at any rate. This enormous amount of air is doubtless brought in by tracheal passages which give it off within the cell-bodies from their free terminations; therein the air is driven into the gland-lumen, where it becomes accumulated to preserve a considerable pressure. The posterior end of the gland being totally blind, this pressure acts on the silken column, so that this force is utilized to shift forwards the latter.

7) The anterior division is not excluded from the silk-production, but secretes, in the embryonal stages, some silken fluid, as in the other two divisions, although the silk secretion is entirely given off, when the embryo hatches out, to be followed by secretion of the chitinous substance which makes up the exceedingly thick intima.

8) During the first age, the cell-nuclei are nearly uniform in shape and size throughout the whole extent of the silk gland: they vary from roundish to ellipsoid. Fuikation of nuclei appears for the first time early in the second age in the anterior division, being not coincident with the observation by HELM.[1]

9) In later stages of the larval life, the nuclei of the anterior division distinctly differ from those of the other divisions in microscopical features: in the former part they are slender, homogeneous, non-granulated and less ramified, while in the latter part they are massive, roughly granulated and complicatedly branched.

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1) F. E. Helm: Ueber die Spinndrüsen der Lepidopteren. *Zeitschr. f. wiss. Zool.* XXVI. 1876. pp 431-469.

10) Cautious measurement shows that the silk-producing surface of the silk glands is absolutely smaller in Japanese races than in European; however, considered in proportion to their body-weight, it is much greater in the former races as compared with the latter. This fact is seen in an excellent parallel with the results by the physiological experiment undertaken in the Tokyo Sericultural Institute: this experiment shows that the European silkworms are, for a given quantity of mulberry-leaf supply, much inferior to the Japanese in respect to the cocoon- and silk-production.

My work is not closed, but is being carried on and extended to the silk glands of some other silk-producing insects, which are nearly allied to *Bombyx mori*. The complete work will soon appear in a future paper.

摘　　要

昨年以來、予は家蠶の絹絲腺に就きて研究し、多少從來の學說と異なりたる結果を得たり。今下に其の概要を摘錄せん。

1) 絲腺と連繫する二對の狹長筋あり、其一は中部絲腺に連なり、他は絲腺の後端に附着す、共に其末端數多の小枝に岐れ、結締組織を以て絲腺の tunica propria と連絡す。此筋肉は絲腺屈曲の方式と重要なる關係を有するものゝ如し。

2) 中部並に後部絲腺には、種々の太さを有する無數の氣管來り附着せり、但前部絲腺は全く氣管と連繫を有せず。此等の氣管は分泌細胞に空氣を供給すると共に、絲腺を其位置に固定するの作用を兼ぬるものなり。氣管は腺の外膜を貫きて深く細胞中に穿入す、其進入するに方りては氣管の突端より分泌する一種の enzyme により外膜の接觸部を溶解するものなるべく、機械的作用によりて之を突破るにあらず。侵入せる氣管は細胞內に在りて幾回も分岐し、遂に輪

環を有せざる細微の毛細管となりて終る。 WISTINGHAUSEN の所謂 "Tracheenkapillarendnetz"は如何なる方法によりても之を發見すること能はざりき。蛻皮に方りては、氣管皮膜細胞と舊輪環との間に新輪環を形成す。此時期の絲腺の斷面に於て氣管中に二重の輪環を認むるは之が爲なり、又一個の新環中に二個の舊環を認むること稀ならず。

3) G. JOSEPH は絲腺に分布せる神經に就きて記載じたれども、予は種々の方法により、斯くの如き神經の存在せざることを確めたり。而して絲腺に附着せる結締組織、氣管の末梢等は一見神經絲に酷似せり、是或は氏が神經と誤信せるものにはあらざるか。

4) Tunica intima は前部に於ては甚厚くして輻射方向に走れる細き條紋を有す。中部に在りては其表面に稍規則正しき平行の條紋を見るも、此の平行線狀紋は後方に向ひて漸次不規則となり、後部絲腺に至れば其傾向益々甚しく、遂に全く網狀紋に移行するものとす。

5) 絲腺內腔に存在する絹絲物質は絲質及び膠質の二部より成る。此二物質の生成に關しては、諸學者の說區々にして殆歸着する所を知らず。就中、膠質が絹絲吐出後、体外に於て生成せらると唱へたる BOLLEY の說は今日、何人も之を信ずるものなく、GILSON の淘汰說亦甚だ首肯し難し。而して現今最汎く行はるゝは次の二說とす、即ち絲質は後部より、膠質は中部より、別々に分泌せらると爲すものと、絲質は後部より分泌せられ、膠質は中部に於て絲質の表面酸化して生じ、中部は分泌力を有せずと爲すもの是なり。然るに予の管見を以てすれば、兩說共に後部に於て膠質を發見し得ざりしに出でたる謬說に外ならず。予は或時期の蠶兒に就きて、後部に於ける膠質の存在を確認し得たるのみならず、他方に於ては中部が絲質分泌の作用を有することも亦疑ふ可からざる證跡あり。是に於て予は次の結論を下さんと欲す、曰く絲質は後部並に中部絲腺より分泌せらる、

絲質は絲腺内腔に於て空氣の影響の下に一部膠質に變せらる、此變化は中部のみならず後部に於ても起るものなり、唯其最永く停滯する部分に於て最多く此空氣の作用を受くるのみと。

6) 分泌せられたる絹絲物質を前方に移行せしむる動力に關しては、殆何等頼るべきの説有るを聞かず。或は曰ふ是filièreの壓出作用と血液の壓力とに因るものなりと。然れども絲腺内に於ける絹絲物質は粘稠なる液体に過ぎざるを以て、filière の壓出力が遠く中部乃至後部に及ぶの理はある可からず。殊に之を血壓に歸するに至りては、一層理由なきことなりとす。何となれば、絲腺は血液中に侵漬しありて、其血液は後方に流るゝを以て、之が絹絲物質の前進を促すの動力たり得べしとは信じ難く、殊に絲腺は前後左右に迂餘曲折せるのみならず、絲腺内腔には絹絲物質と分泌細胞との間に大なる空處ありて、外壓の直接、絹絲物質に及ぶの理なければなり。予の觀る所に依れば、分泌細胞内に無數に存在せる氣管毛細管より放出せられたる空氣は、tunica intima を通じて一部絲腺内腔に出で來り、絹絲物質上に壓力を及ぼす、然るに絲腺後端は盲管に終るを以て、此壓力は專ら絹絲物質を前方に推進するの動力と爲るものなり。尚絲腺の内腔に多量の空氣蓄積せるは絹絲物質中に發見せらるゝ無數の氣泡に徵しても明なりとす。

7) 前部絲腺は胚子時代に在りては、他の兩部と同じく絹絲物質を分泌するも、蠶卵孵化後に至れば其作用を失ひ、專ら chitin 質の分泌を掌る。分泌せられたる chitin 質は蓄積して前部に特有なる厚き intima を形成す。

8) 細胞核は第一齢中に在りては、絲腺全部を通じて其形態殆相等しく、球形乃至楕圓体形を呈す。第二齢に至れば前部の細胞核は早く既に分岐を始むるも、中部並に後部に在りては第四齢に入り初めて細胞核の分岐を始むるものとす。

9) 成長せる蠶兒に在りては、前部絲腺の細胞核は中部の細胞核と大に其形態を異にす。即ち前者は分岐、比較的簡單にして、各部の太さ殆相等しく、顆粒を認めず、之に反して後者は分岐、不規則複雜を極め、各部の太さ甚不同にして、組織は粗顆粒狀を呈せり。

10) 本邦種家蠶の絲腺の發達は之を歐州種に比すれば其絶對量に於て稍劣れり。然れども一定の給桑量に對する割合に於ては、前者は遙に後者に優れり。是品種改良上頗る注目すべき事實と曰ざる可からず。